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IT Outsourcing – A Source of Innovation? Microeconometric Evidence for Germany

Irene Bertschek and Daniel Erdsiek

ZEW

Zentrum für Europäische
Wirtschaftsforschung GmbH

Centre for European
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Non-technical summary

In 2006, on average 43% of the firms in the EU-15 practiced IT outsourcing (ITO). The determinants of ITO as well as firms' incentives to source out non-core activities have been examined extensively. As summarised by Lacity et al. (2010), the most important motive for ITO is "the desire to reduce cost on a non-core IT activity better provided by suppliers with superior skills, expertise, and technical capabilities". Less research focused on the impact of ITO on firm performance.

In this study, we analyse whether ITO increases a firm's probability of realising product or process innovations due to setting free resources that can be redirected to core competencies such as innovation activity. For our empirical analysis, we use two waves of the ZEW ICT survey, 2007 and 2010, comprising 1453 firms from the manufacturing and the services sector in Germany. The data set allows to employ different measures of ITO taking into account that the degree of outsourcing might matter and that there might be nonlinear relationships between ITO and innovation activity. By splitting our estimation sample in manufacturing and services firms we furthermore explore whether the impact of ITO on innovation activity differs between manufacturing and services firms given the fact that business processes are generally more IT intensive in services firms.

The econometric probit analysis shows a significant and U-shaped relationship between ITO and the product innovation activity of manufacturing firms. In the service sector, by contrast, we find a significant and hump-shaped relationship between ITO and the realisation of process innovation. Applying a propensity score matching approach takes account of potential reverse causality between ITO and innovation; the results underpin the importance of ITO for services firms' realisation of process innovation.

Das Wichtigste in Kürze

Im Jahr 2006 lagerten im Durchschnitt 43% der Unternehmen in den EU-15 Ländern IT-Dienstleistungen an externe Anbieter aus. Die Determinanten des IT-Outsourcing (ITO) sowie die Anreize zur Auslagerung von Aufgaben, die nicht zu den Kernkompetenzen eines Unternehmens gehören, wurden bereits in zahlreichen Studien untersucht. Weniger ist bislang bekannt über die Auswirkungen des ITO auf den Unternehmenserfolg.

In dieser Studie untersuchen wir, ob ITO die Wahrscheinlichkeit erhöht, dass Unternehmen Produkt- oder Prozessinnovationen realisieren. ITO kann dazu beitragen Ressourcen freizusetzen, die Unternehmen vorzugsweise auf die Innovationsaktivität als ihre Kernkompetenz konzentrieren. Für die empirische Analyse nutzen wir zwei Wellen der ZEW IKT-Umfrage aus den Jahren 2007 und 2010, die Unternehmen aus dem verarbeitenden Gewerbe und dem Dienstleistungssektor in Deutschland umfassen. Wir verwenden verschiedene Maße für ITO, die u.a. die Outsourcingintensität messen. So wird berücksichtigt, dass die Beziehung zwischen dem Innovationserfolg und ITO nichtlinear verlaufen kann. Außerdem ermöglicht die getrennte Betrachtung von verarbeitendem Gewerbe und Diensleistungsgewerbe, systematische Unterschiede zwischen diesen Sektoren zu berücksichtigen, die beispielsweise daher rühren, dass Dienstleistungsunternehmen in der Regel IT-intensivere Geschäftsprozesse aufweisen als verarbeitende Unternehmen.

Die Ergebnisse der ökonometrischen Analyse ergeben eine signifikante und U-förmige Beziehung zwischen ITO und der Realisierung von Produktinnovationen im verarbeitenden Gewerbe. Im Dienstleistungssektor hingegen finden wir eine signifikante und umgekehrt U-förmige Beziehung zwischen ITO und Prozessinnovationen. Der Ansatz des ‘propensity score matching’ erlaubt die potenzielle umgekehrte Kausalität zwischen Innovationsaktivität und ITO zu berücksichtigen. Das Ergebnis untermauert die signifikante Rolle von ITO für die Realisierung von Prozessinnovationen in Dienstleistungsunternehmen.

IT Outsourcing - A Source of Innovation? - Microeconometric Evidence for Germany[§]

Irene Bertschek* and Daniel Erdsiek[†]

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Abstract

Do firms sourcing out IT services redirect their resources to innovation activity? We attempt to answer this question by analysing a firm-level data set comprising 1453 firms from the German manufacturing and services sectors. Using different measures of IT outsourcing (ITO), the econometric estimations reveal a significant and U-shaped relationship between ITO and product innovation activity of manufacturing firms, and a significant and hump-shaped relationship between ITO and process innovation activity of services firms. A propensity score matching analysis takes account of reverse causality; the results underpin the relevance of ITO for services firms' realisation of process innovation.

JEL codes: D22, L23, O31

keywords: IT outsourcing, product innovation, process innovation, firm-level data

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*ZEW Mannheim and University of Mannheim, email: `bertschek@zew.de`. Corresponding author, address: Centre for European Economic Research (ZEW), ICT Research Group, P.O. Box 103443, 68034 Mannheim, Germany.

[†]ZEW Mannheim, `erdsiek@zew.de`.

1 Introduction

In 2006, on average 43% of the firms in the EU-15 sourced out IT services to external service providers (see Figure 1). This share varies between 20% in Greece and 78% in Denmark. Within countries there might be a large variation with respect to IT outsourcing across industries as the boxplots in Figure 1 indicate.

According to Lacity et al. (2010) the most important motive for information technology outsourcing (ITO) is “the desire to reduce cost on a non-core IT activity better provided by suppliers with superior skills, expertise, and technical capabilities”. As regards the outcome of ITO empirical results are less concise, however with a major proportion of studies showing evidence for positive outcomes.

Our study contributes to the literature in three respects: First, we consider innovation activity as a firm’s core competence and analyse the question whether ITO supports innovative activity because firms have more capacity to concentrate on. Second, we use different measures of ITO: (i) a binary variable, (ii) two dummies, one for partial outsourcing and one for complete outsourcing, (iii) the percentage of IT services sourced out to external service providers. This allows taking account of nonlinear relationships between ITO and the performance measure. Third, we differentiate between manufacturing and services firms in order to take into account systematic differences. Services firms are generally more IT intensive and thus might depend more on a well functioning IT infrastructure than do manufacturing firms. Our analysis is based on a German data set comprising 1453 firms from manufacturing sectors and from services sectors.

Beyond probit estimations, we conduct a propensity score matching analysis in order to account for possible reverse causality between ITO and innovation activity.

As a preview to our results, we show that

- ITO plays a significant role for product innovation of manufacturing firms and for process innovation in services firms.

- The results obtained by probit estimations suggest a nonlinear relationship with ITO which is U-shaped in the case of product innovation in manufacturing firms and inverted U-shaped in case of process innovation in services firms.
- The results from the propensity score matching approach underpin the finding of a positive effect of ITO on the realisation of process innovation in services firms.

2 IT Outsourcing and Innovation

Advances in IT are a key driver of service outsourcing[1] at the national level and at the international level (Abramovsky and Griffith, 2006). Owing to this technological progress firms are faced with the obsolescence of their technical equipment and know-how (see for example, Bartel et al. (2009)). As a consequence, a lot of firms source out IT services such as the maintenance of hardware, or software programming, to external service providers. The determinants of ITO are well studied, most of the studies belonging to the information systems literature. The most recent and comprehensive review of this literature is provided by Lacity et al. (2010). They reviewed 164 empirical — quantitative and qualitative — articles and coded their findings. They consider articles focussing on the determinants of ITO decisions and on the outcomes of ITO. The results with respect to the determinants of ITO show that the main motive for ITO is to concentrate on core competencies while accessing the expertise of external specialised service providers.

From most firms' perspective, IT services are viewed as non-core activities. ITO allows them to concentrate on other, more crucial activities such as innovation or marketing. By specialising, ITO providers achieve economies of scale and keep pace with technological advances. This in turn allows outsourcing firms to reduce costs and to flexibly access new technologies. According to the transaction cost theory (Williamson, 1985) outsourcing is associated with costs for search and information,

[1]See for instance Görg et al. (2010) for the specificities of service outsourcing.

transition and monitoring.[2] These costs might outweigh the advantages of outsourcing. Lacity et al. (2009) summarise findings indicating that the impact of ITO on different measures of success depends on the share of IT services being outsourced. In particular, partial outsourcing of IT services is more strongly related to positive outcomes than complete ITO.

Some microeconometric studies investigate the impact of ITO on labour productivity or employment at the firm level. For example, Ohnemus (2007) shows positive effects of ITO on firms' labour productivity and on the productivity of employees working on computers. His analysis is based on a sample of German firms from the manufacturing and services sectors. Maliranta et al. (2008) find similar results based on Finnish business-level data. Moreover, in the medium run, IT outsourcing firms can increase their employment (Ohnemus, 2010). Using German firm-level data for the year 2000 and a broad definition of ITO, Bertschek and Müller (2006), by contrast, find that firms without ITO are significantly more productive than those with ITO.

Our study addresses the question whether or not firms profit from ITO in terms of being more innovative. Innovation activity is a core competence and a prerequisite for firms' productivity growth and competitiveness. By sourcing out IT services a firm can save costs and redirect capacities towards innovation activities. As regards the firm-level relationship of ITO and innovation activity, there is to the best of our knowledge only the paper by Peukert (2011). Using data from 1582 German firms for the years 2003 and 2006 he finds a positive relationship between process innovation and ITO and a positive and nonlinear relationship between product innovation and ITO.

Glass and Saggi (2001) suggest an analytical framework for international outsourcing and its effects on innovation activity. Cost reduction and increasing profits allow firms to innovate more. By contrast, Leahy and Motagna (2008) focus on

[2] An overview of the theoretical literature on IT outsourcing is given for instance by Dibbern et al. (2004) and Lacity et al. (2009).

the relationship between domestic outsourcing costs and profits. According to their oligopoly model outsourcing may lead to higher cost and less profits. Based on these contrary theoretical hypotheses Görg and Hanley (2011) analyse the role of domestic and international service outsourcing for profits and innovation activity of Irish plants. Using a sample of about 1700 plants for the period from 2002 until 2004 they find that international service outsourcing is positive for profits and for R&D activity. The effect of domestic outsourcing on R&D activity is also positive but smaller than in the case of offshoring.

Our paper focuses on the relationship between ITO and the innovation activity of German firms. We consider realised product and process innovation as measures of innovation output and use different measures of ITO. Furthermore, we look for systematic differences between manufacturing and services firms since we assume that business processes of services firms depend more strongly on a well-functioning IT infrastructure. Based on the presented literature, we formulate the following hypotheses for our empirical analysis:

> **Hypothesis 1:** *ITO is positively related with a firm's innovation activity. Redirecting and concentrating resources on core competencies increases the likelihood of realising* ***1a)*** *product innovations and* ***1b)*** *process innovations.*

> **Hypothesis 2:** *The relationship between ITO and innovation activity depends on the degree of ITO so that nonlinear effects occur.*

> **Hypothesis 3:** *The relationship between ITO and innovation activity differs between manufacturing and services firms due to systematic differences in using IT and distinct levels of IT intensity.*

3 Econometric Implementation

The focus of our empirical analysis is on how firms' innovation activity is related to IT outsourcing. Innovation activity is measured as a binary variable taking the value one if an innovation has been realised and the value zero otherwise. The probability of realising a process innovation or product innovation is assumed to be determined by ITO as well as by various other factors $\mathbf{X}$ well-known from the empirical literature on innovation. For firm i, the relationship is specified as:

$$\Pr[Y_i^j = 1|ITO, \mathbf{X}] = \Phi(\alpha + \beta_{ITO} ITO_i + \beta_{\mathbf{X}} \mathbf{X_i}) \tag{1}$$

with $j\epsilon\{IC, ID\}$ and IC = process innovation and ID = product innovation, and $\Phi(\cdot)$ representing the cumulative normal distribution function. ITO is thus assumed to positively shift firm i's probability to innovate. The matrix $\mathbf{X}$ comprises firm size measured as number of employees as a driver of innovation, capital investment, and IT intensity.[3] A dummy variable indicating whether or not a firm exports its products and services controls for international competitive pressure. Previous innovation success is included to account for the persistence of innovation activity (see for instance Flaig and Stadler (1994) and Peters (2009)). Finally, two-digit sector dummies and a regional dummy (East/West Germany) are included in order to control for sector-specific and regional effects. The next section gives a more detailed description of the data.

In a first step, we apply probit estimation since the dependent variables are binary. We do this separately for product and process innovation as dependent variables, for all sectors as well as separately for manufacturing and services.

Outsourcing IT services might be part of a firm's strategy and therefore possibly endogenous with respect to innovation activity, i.e. innovating firms may be more likely to engage in ITO than non-innovating firms. Therefore, in the next step, we infer the effects of ITO on a firm's innovation activity by conducting a matching analysis. In this quasi-experimental design ITO is interpreted as a treatment and a firm of the treatment group (ITO) is matched with firms from the control group (non-ITO) which are very similar to the ITO firm with respect to observed charac-

[3] See for instance Brynjolfsson and Saunders (2010) for the innovation enabling character of IT.

teristics. Since ITO firms and non-ITO firms can not be perfectly matched ("curse of dimensionality"), we employ the method of propensity score matching (Rosenbaum and Rubin, 1983).

In the first step of the matching procedure for every firm the propensity score is estimated through a probit regression of the ITO dummy on all explanatory variables in the model. A prerequisite for employing matching methods is that the conditional independence assumption (CIA) holds (Rubin, 1977). This implies that conditional on the estimated propensity score the treatment participation (i.e. ITO) is random and independent from the treatment outcome (i.e. innovation activity). If the CIA is satisfied we can infer the counterfactual innovative outcome of ITO firms by examining non-ITO firms with similar propensity scores. Therefore, in the second step, each IT outsourcing firm is matched with one or more non-ITO firms ("next neighbours") exhibiting the closest propensity score. The mean difference in the outcome variable innovation activity between ITO firms and their non-ITO counterparts then indicates the average treatment effect on the treated (ATT).

4 Data and Descriptive Analysis

For the empirical analysis we use two waves of the ZEW ICT survey, a representative business survey carried out by the Centre for European Economic Research (ZEW) in 2007 and 2010. Most of the survey questions refer to the years 2006 and 2009, respectively.[4]

The sample is stratified according to sectors, size classes with respect to number of employees, and regions (East/West Germany). Each wave comprises 4,400 firms located in Germany with at least five employees. The data set contains detailed information on the use of ICT applications, innovation activity, sales, number and qualification structure of employees and many further firm characteristics.

[4]The data are available at the ZEW Data Research Centre ZEW-FDZ.

Realised *process innovation* is measured by a dummy variable, indicating whether a firm has internally introduced new or significantly improved processes between the years 2007 to 2009. Realised *product innovation* accordingly measures whether the firm has introduced new or significantly improved products or services.[5] The precise questions asked to the firms are:

- *Has your firm brought new or significantly improved products or services to the market between 2006 and 2009?*
- *Has your firm introduced internally new or significantly improved processes between 2006 and 2009?*

Moreover, we take account of the "success breeds success" hypothesis by including innovation activity from the previous period and thus controlling for firms' previous experience in innovation.

The question referring to IT outsourcing is: *If you consider all IT services needed by your company in 2006, what was the share provided by external service providers? IT services comprise for instance hardware maintenance, software programming, leasing, etc.*

From this share, we derive three alternative measures of IT outsourcing: The dummy variable *ITO dummy* takes the value one if a firm has outsourced IT services.

ITO partially is a dummy taking the value one if IT services are partially sourced out whereas *ITO completely* takes the value one if firms practice complete IT outsourcing.

Finally, the variable *% share of ITO* is the proportion of IT services provided by external service suppliers.

Firm size is captured by the *number of employees.* Since some empirical evidence hints to a nonlinear relationship between innovation success and firm size, we additionally include the squared firm size. Investment is measured as *total investment* in

[5]The definitions follow the OSLO manual (OECD and Eurostat, 2005) and correspond to the definition used in the Community Innovation Survey (CIS).

million euros. A firm's *IT intensity* is measured as the percentage share of employees working predominately at a computer.

The qualification of employees is captured by the proportion of employees being *high-skilled* (degree from university, university of applied sciences or university of cooperative education) or *medium-skilled* (master craftsman, technicians, persons having successfully completed vocational training). Low-skilled (without formal qualification) workers are the reference category.

For the matching analysis, we employ three additional variables that could impact the propensity of ITO at the firm-level. The proportion of employees being IT specialists is captured by the variable *% IT specialists*. The *consortium dummy* indicates whether a firm is part of a group of firms (multi-establishment company). Moreover, we take into account local supply of IT services (*log(local IT suppliers)*) by measuring the number of IT-services suppliers located in the same region as a surveyed firm. This variable was obtained by selecting all firms with NACE code 62 (IT service provision) and 63 (provision of information services) from a data base provided by Creditreform, Germany's largest credit rating agency. The data base yields information about the residence of IT-services suppliers in Germany. This information has been merged with the survey data at the three-digit county level (according to the so-called "Kreiskennziffer"). In total, we have 40 counties at the three-digit county level. Arora and Forman (2007) analyse the role of local IT services markets for U.S. establishments' probability to source out IT services. They find that sourcing out programming and design services is positively affected by the local supply of such services suggesting that these services consist of non-tradeable or local components that need more face-to-face interaction.

While the dependent innovation variables result from the 2010 wave of the ICT survey and refer to innovation activity in the period 2007 to 2009, all explanatory variables are taken from wave 2007. This takes into account the time lag of measures like investment or training to impact innovation.

Descriptive statistics for the full estimation sample are presented in Table 1. On average, 56% of the firms in the sample have realised at least one product innovation within the years 2007 and 2009, and 60% have realised a process innovation. Almost two third of the firms (73%) have sourced out IT services. The mean share of IT services outsourced is 37%. Most firms source out only partially (57% of the firms) whereas 17% of the firms practice complete ITO. The average number of employees in the sample is 126, so the sample mainly consists of small and medium-sized enterprises. About 49% of the employees predominately work with computers.

Additionally, a set of dummy variables controls for differences across location (East or West Germany), export activity and sector affiliation. On average, 35% of the firms in the estimation sample are located in East Germany, 48% of the firms export their products or services to foreign countries.

According to Table 2, manufacturing firms in our sample had a larger share of product innovators (65%) than services firms (47%) in 2010. They do not differ considerably with respect to ITO. The workforce in services firms is characterised by higher qualification and a more IT-intensive way of working. Therefore, services firms have a higher percentage of IT specialists (15% compared to 4%). More manufacturing than services firms are exporters (68% compared to 30%).

Table 3 presents the distribution of firms across industries in our estimation sample and in the complete data set from 2010 containing all interviewed firms. The distributions across industries do not differ severely from each other such that we can assume to work with a sample which is representative with respect to industries.

5 Empirical Results

5.1 Probit Regression

In this section, we empirically test our three hypotheses concerning the relationship between ITO and the innovation activity of firms. Table 4 shows the raw effects obtained when regressing product and process innovation on the different measures of ITO. The simple ITO dummy is positive and significant only for process innovation. Using the ITO dummies representing partial and complete ITO and neglecting other explanatory variables at this stage of the analysis reveals that ITO is nonlinearly related to innovation activity. If a firm outsources its IT services completely to external service providers, the firm does not seem to profit from this firm strategy since transaction cost may increase considerably. This result is supported when continuous shares of ITO are considered in specifications (3) and (6) of Table 4. In the next step, we will analyse how these effects change if we include further explanatory variables.

Product Innovation

The estimation results for product innovation are presented in Table 5 for the full sample and in Table 6 separately for manufacturing and services firms. For the full sample, ITO shows a negative and slightly significant effect when measured as a simple dummy (specification (1)). The relevance of the degree of ITO is taken into account in specifications (2) and (3). When considering separate dummies, one for partial ITO and one for complete ITO, only the dummy for partial ITO is negative and slightly significant (specification 2). In the third specification, the ITO coefficient is negative and slightly significant when measured as shares of IT services that are outsourced. All other variables show the expected signs. Previous innovation activity is important for current innovation (success breeds success hypothesis), firms of larger size, investing more and exporting are more likely to realise product innovation. The share of employees working with computers is positively related to product innovation but only at a 10% significance level. IT training, by contrast, is positive and highly significant for the realisation of product innovation.

In order to reveal systematic differences between manufacturing and services firms, we run the same regressions separately for the two groups of firms. As Table 6 shows, the ITO dummies are now insignificant in all specifications. Only the share of outsourced IT services is significant for manufacturing firms. It shows a U-shaped relationship between product innovation and ITO implying that manufacturing firms' probability to innovate first decreases and then increases with the share of outsourced IT services. For services firms, ITO does not have any significant effects on product innovation. These results contradict hypothesis H1a suggesting that ITO increases the likelihood of realising product innovations.

Process Innovation

Turning to the case of process innovations, results look different. According to Table 7 all three types of measuring ITO reveal positive and significant coefficients similar to the raw regressions although with coefficients of smaller size and lower significance levels. Outsourcing IT services increases the likelihood of realising process innovations about 6% which is in favour of hypothesis H1b. However, specification (2) indicates a significant impact only for partial ITO while complete ITO does not increase a firm's probability of realising process innovation. Additionally, the third specification hints to a nonlinear inverted U-shaped relationship implying that the probability of realising a process innovation first increases then decreases with the share of outsourced IT services. In line with hypothesis H2, these results show that the degree of ITO matters. As outlined before, transaction costs might be high in case of intensive outsourcing and thus not profitable for firms' innovation capabilities when passing a certain threshold. Further significant variables are previous process innovation, IT training, and the share of employees working with computers.

Running the same regressions for manufacturing and services separately (Table 8), the ITO variables turn out to be insignificant for manufacturing firms but stay significant for services firms. This favours H3 and seems plausible given the fact that services firms are more IT intensive and thus are more dependent on competent IT service supply. For manufacturing, by contrast, business process outsourcing (BPO) turns out to be more important than ITO. Sourcing out business processes such as accounting or human resource management gives manufacturing firms the possibility to redirect resources into process innovation activity.

Summarising these results, we find that in the case of product innovation, ITO plays a significant role only for manufacturing firms whereas in the case of process innovation it turns out to be an important firm strategy only for services firms. The results for process innovations in services firms indicate a nonlinear inverted U-shape and are more robust in terms of significance of coefficients and different measures of ITO. For product innovations in manufacturing firms, the results indicate a U-shape relationship with ITO, however, only if ITO is measured by the share of outsourced IT services. Our results differ from those of Peukert (2011) in the following respects: As regards product innovation, our analysis hints to a U-shaped relationship with ITO whereas Peukert (2011) finds a hump-shaped relationship. For process innovation, our results suggest a hump-shaped relationship whereas Peukert (2011) finds a linear one. The advantage of our analysis is that our data explicitly contain expenditure shares of ITO. Peukert (2011) using a previous wave of the ZEW ICT survey had to construct these shares by taking certain assumptions about the ITO intensity and using the share of employees working predominately with computers as a weighting scheme.

Robustness Checks

All estimations were also performed assuming a linear probability model and applying OLS estimation. Since the results do not differ qualitatively, we do not present them here.

A possible reason for the significant effect of partial ITO on process innovation could be that firms extend ITO during the time span our innovation variable refers to (2007 to 2009) and define this change as process innovation. As a robustness check, we exploit information on ITO activity observed in the 2010 wave of the survey and referring to 2009. We find strongly significant positive effects on process innovation for firms increasing ITO as well as for firms holding ITO constant between 2006 and 2009. This result underpins the findings from using only information on ITO activity from the 2007 wave of the survey.[6]

[6] Results are available from the authors upon request.

5.2 Propensity Score Matching

Although lagged explanatory variables are included in the previous probit regressions concerns about endogeneity may endure. In order to account for possible reverse causality between ITO and innovation activity, we conduct a matching analysis. The following section describes the results from propensity score matching and the robustness of previous findings.

The first step of the matching procedure is the estimation of the likelihood that a firm sources out IT services. Subsequently, these probit estimation results are used to calculate the propensity score for each firm. In order to fulfill the CIA, implying that conditional on the propensity score the treatment of ITO is randomly assigned, we additionally include three further variables for explaining the outsourcing decision. The variables *share of IT specialists* and *consortium dummy* capture additional firm characteristics which may be associated with firm strategies incorporating both innovation activity and ITO. In contrast, *log(local IT suppliers)* measures the supply in local IT services markets which is suggested to influence prices for ITO and therefore a firm's outsourcing decision.[7]

Table 9 shows the first step probit regression results for process innovation. For the full sample the share of employees being IT specialists is negatively correlated with ITO whereas a positive relationship is indicated for the number of local IT-services suppliers. If the sample is split, the coefficients of both variables remain significant for services firms but become insignificant for manufacturing firms. Being part of a group of firms is significantly and negatively correlated with ITO for services only.[8] Furthermore, a firm's likelihood to outsource IT is significantly and positively related to BPO, IT training, the share of employees using a computer, gross investment and exporting. A nonlinear inverted U-shape relation is indicated for the number of

[7] See the study by Arora and Forman (2007) showing that some IT services need more personal interaction between outsourcing firm and service provider, and therefore corresponding IT services markets are more local.

[8] Raw effects show a significant positive relation between the consortium dummy and ITO. However, the coefficient becomes negative if the number of employees as well as gross investment are controlled for.

employees, such that the positive effect of the firm's size decreases for large firms.

Since perfect matching with respect to all observed firm characteristics is not feasible ("curse of dimensionality"), our matching procedure is based on the propensity score (Rosenbaum and Rubin, 1983). We match every ITO firm with five non-ITO firms ("nearest neighbours") exhibiting propensity scores with the shortest distances to the propensity score of the ITO firm. Thus, after matching, ITO firms and non-ITO firms should not differ in any observed explanatory characteristic except of ITO. If this is yield by the matching procedure and the CIA holds, the counterfactual innovative activity of ITO firms can be inferred from their twin non-ITO firms.

Sample means before and after matching are shown in Table 10 for the full sample of ITO and non-ITO firms. In the unmatched case, firms sourcing out IT services strongly differ from non-ITO firms with respect to observable characteristics. Mean differences are highly significant in all observed characteristics except for the share of employees using a computer. After matching, however, mean differences between ITO and matched non-ITO firms become insignificant. Our matching procedure, therefore, seems to appropriately match ITO firms with control firms almost identical with respect to observed characteristics.[9] In combination with our assumption, that conditional on the observed characteristics ITO is randomly assigned to firms (CIA), we are able to infer causal effects. Restricting the sample of ITO firms to those that have a common support with non-ITO firms, only 33 ITO firms are off support so that a total of 1,033 ITO firms is compared to 387 non-ITO firms.

The matching analysis can be employed to test hypotheses H1 and H3 while accounting for possible endogeneity. Since the treatment variable is a dummy indicating whether or not a firm sources out IT services, nonlinear effects cannot be inferred. Therefore, H2 cannot be tested using this matching approach. Table 11 shows the average treatment effect of ITO on the treated (ATT) distinguishing between type of innovation and sample used.[10] In the case of product innovation, we find no

[9] Results for product innovation do not differ qualitatively.

[10] Increasing or decreasing the number of nearest neighbours did not change the results considerably for process innovation as well as for product innovation.

significant causal effects of ITO. The mean differences between ITO and non-ITO firms are negative but insignificant for the full sample as well as for the split samples. This result does not fully support the probit estimates which pointed to a negative effect of ITO on product innovation for manufacturing firms. Additionally, the estimated ATTs contradict H1a assuming that ITO increases a firm's likelihood to realise product innovations.

Turning to process innovations, the matching analysis confirms the probit results with respect to the linear effects of ITO. The mean differences after propensity score matching imply that ITO significantly increases the probability of realising process innovations for services firms whereas this does not hold for manufacturing firms. The significant ATTs for the full sample (8.8%) and the services sample (12.8%) are only slightly higher than the respective probit estimates. Thus, even if possible endogeneity is accounted for, we find a positive effect of ITO on the likelihood of realising process innovations confirming H1b.

Finally, the matching results also support hypothesis H3 in the sense that ITO is a crucial determinant of process innovations for services firms only.

6 Discussion and Conclusions

6.1 Findings

The purpose of the paper is to provide empirical evidence on the relationship between innovation and IT outsourcing. Although there is already a vast literature on the determinants of ITO and its impact on firm performance, not much empirical research deals with the innovation capabilities of firms and with differences between manufacturing and services firms. We provide econometric evidence based on a unique firm-level data set comprising manufacturing and services firms located in Germany with at least five employees. This data allows to construct various measures of ITO.

Based on previous literature and transaction cost theory, we assume that ITO increases a firm's likelihood to realise innovations (H1). Probit estimations reveal that ITO plays a significant role for product innovations of manufacturing firms and for process innovations of services firms. A matching analysis accounts for possible reverse causality between ITO and innovation activity. Since a dummy variable indicating whether a firm sourced out IT services is employed as treatment variable, only causal linear effects can be inferred by our matching analysis. We find no causal linear effect of ITO in the case of product innovation contradicting H1a. In contrast, the estimated ATT of ITO is positive and significant for process innovations of services firms which is in favour of H1b.

We also test whether the degree of ITO is crucial for the impact of ITO on innovation activity (H2). The probit estimates suggest a nonlinear relationship which is U-shaped in the case of product innovations and inverted U-shaped in case of process innovations. Both results seem to be plausible if one considers the business processes of manufacturing versus those of services firms. Services firms are characterised by a high IT intensity compared to manufacturing firms. They highly depend on a well-functioning IT infrastructure. IT services are rather core activities of services firms. ITO thus supports services firms in reshaping and optimising their IT-intensive business processes resulting in improved innovative capabilities with respect to processes, but not with respect to products. The results for process innovations of services firms are in line with previous studies indicating that selective ITO is more strongly related to different measures of ITO success than complete ITO (Lacity et al., 2009). If ITO increases beyond a certain threshold, cost savings might be outweighed by an increase in monitoring cost.

In manufacturing firms, by contrast, ITO seems to bind resources that are redirected from product innovation activities. Only when reaching a certain threshold of ITO firms start to increase their probability of realising product innovation. Considering IT services as non-core activities of a manufacturing firm, a high share of outsourced IT services gives the opportunity to concentrate on product innovation as a core activity. Moreover, for manufacturers' process innovations, business process outsourcing (BPO) turns out to play a more important role than ITO. This result again is consistent with the fact that business processes in manufacturing firms are generally less IT intensive than in services firms. We conclude that for analysing the effects of ITO on innovation activity distinguishing between manufacturing and services firms is crucial.

6.2 Limitations and Future Research

Although we use explanatory variables with a time lag in our probit estimations, there might be endogeneity of ITO in the sense that the more innovative firms are those that invest more in ITO. Therefore, we applied the approach of propensity score matching. This method has some advantages over simple linear regression. It better balances treatment and control group by considering only those observations with common support in the explanatory variables. Moreover, it does not require an assumption about the functional relationship between innovation activity and ITO. Its identification strategy, however, relies on selection on observables, i.e. we have to assume that we included all variables explaining a firm's propensity to practice ITO such that given these variables, firms are supposed to be randomly assigned to belonging to the group of ITO or non-ITO firms. This so-called CIA assumption is very strong. There might be factors of unobserved heterogeneity such as for example management practices affecting firms' outsourcing decision that we cannot take into account. So, future studies should use panel data, if available, to take into account unobserved heterogeneity.

Secondly, our data refers to German firms only. Since the German economy is characterised by a large amount of SMEs and a strong manufacturing sector, these results might be generalisable to countries with similar economic structure only. We have seen in the introduction, however, that countries differ a lot with respect to their ITO activities. Further comparable analysis for other countries would thus be helpful.

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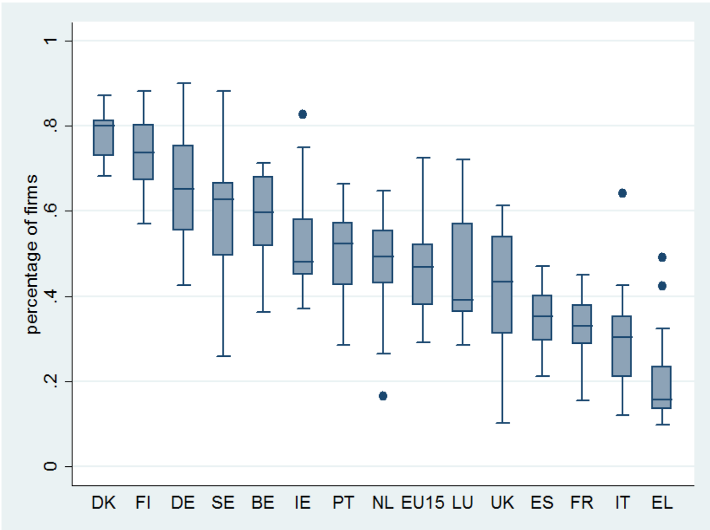
A Appendix

Figure 1: Percentage of Firms with ITO, 2006, Means and Standard Deviations



Data source: EUROSTAT, 2007.

Table 1: Descriptive Statistics, Full Estimation Sample

Variable	**Mean**	**SD**	**Min**	**Max**
Product innovation 2010	0.56	0.50	0	1
Product innovation 2007	0.60	0.49	0	1
Process innovation 2010	0.64	0.48	0	1
Process innovation 2007	0.65	0.48	0	1
ITO dummy	0.73	0.44	0	1
ITO partially	0.57	0.50	0	1
ITO completely	0.17	0.37	0	1
% share of ITO	0.37	0.39	0	1
BPO dummy	0.52	0.50	0	1
IT training	0.63	0.48	0	1
% employees using computer	0.49	0.34	0	1
% high-skilled employees	0.23	0.26	0	1
% medium-skilled employees	0.60	0.27	0	1
Number of employees	126.45	302.18	5	3600
Log(gross investment)	-1.79	1.99	-7.82	6.40
Export dummy	0.48	0.50	0	1
East dummy	0.35	0.48	0	1
% IT specialists	0.09	0.21	0	1
Local IT-suppliers	3782.842	3114.94	233	11877
Consortium dummy	0.14	0.35	0	1
Number of observations	1453			

Data source: ZEW ICT survey 2007 and 2010.

Table 2: Descriptive Statistics, Manufacturing and Services

	Manufacturing		Services	
Variable	**Mean**	**SD**	**Mean**	**SD**
Product innovation 2010	0.65	0.48	0.47	0.50
Product innovation 2007	0.70	0.46	0.52	0.50
Process innovation 2010	0.64	0.48	0.63	0.48
Process innovation 2007	0.67	0.47	0.64	0.48
ITO dummy	0.75	0.44	0.72	0.45
ITO partially	0.59	0.49	0.55	0.50
ITO completely	0.16	0.37	0.18	0.38
% share of ITO	0.36	0.39	0.37	0.40
BPO dummy	0.50	0.50	0.55	0.50
IT training	0.60	0.49	0.65	0.48
% employees using computer	0.34	0.25	0.63	0.36
% high-skilled employees	0.15	0.17	0.30	0.30
% medium-skilled employees	0.62	0.23	0.57	0.30
Number of employees	130.09	276.28	122.97	325.21
Log(gross investment)	-1.55	1.96	-2.02	1.99
Export dummy	0.68	0.47	0.30	0.46
East dummy	0.35	0.48	0.34	0.47
% IT specialists	0.04	0.07	0.15	0.27
Local IT-suppliers	3491.58	2882.92	4059.82	3297.99
Consortium dummy	0.27	0.45	0.40	0.49
Number of observations	707		746	

Data source: ZEW ICT survey 2007 and 2010.

Table 3: Industries, Full Sample and Complete Data Set from 2010

	Full Sample		**Data Set 2010**	
Industry	**obs.**	**% of sample**	**obs.**	**% of data set**
Consumer goods	128	8.81	544	13.04
Chemical and pharmaceutical industry	67	4.61	175	4.20
Other raw materials	97	6.68	295	7.07
Metal industry	106	7.30	273	6.54
Electrical engineering	154	10.60	322	7.72
Machine construction	90	6.19	291	6.98
Vehicle construction	65	4.47	172	4.12
Retail trade	85	5.85	258	6.18
Wholesale trade	80	5.51	187	4.48
Transportation	99	6.81	254	6.09
Media services	32	2.20	186	4.46
IT and other information services	155	10.67	281	6.73
Financial and insurance activities	81	5.57	229	5.49
Real estate activities	34	2.34	134	3.21
Business consultancy and advertising	36	2.48	151	3.62
Technical services	103	7.09	252	6.04
Other business services	41	2.82	168	4.03
Number of observations	1453		4172	

Data source: ZEW ICT survey 2007 and 2010.

Table 4: Product and Process Innovation, Raw Effects of ITO Variables, Full Sample

	Dependent Dummy Variables:					
	Product Innovation			**Process Innovation**		
ITO dummy	0.020			0.137***		
	(0.68)			(4.69)		
ITO partially		0.058*			0.177***	
		(1.89)			(6.03)	
ITO completely		-0.106***			0.000	
		(-2.60)			(0.00)	
% share of ITO			0.278*			0.843***
			(1.85)			(5.65)
(% share of ITO)^2			-0.394***			-0.867***
			(-2.63)			(-5.84)
Number of observations	1453	1453	1453	1453	1453	1453

Probit estimations, marginal effects (at the average), t-values in brackets.
Significant at 1% ***, significant at 5% ** , significant at 10% *

Table 5: Estimation Results, Product Innovation, Full Sample

	Dependent Variable: Product Innovation 2010		
ITO dummy	-0.064*		
	(-1.78)		
ITO partially		-0.069*	
		(-1.82)	
ITO completely		-0.051	
		(-1.06)	
% share of ITO			-0.303*
			(-1.68)
(% share of ITO)^2			0.267
			(1.50)
Product innovation 2007	0.355***	0.356***	0.354***
	(12.16)	(12.17)	(12.11)
BPO dummy	-0.004	-0.004	-0.005
	(-0.14)	(-0.15)	(-0.15)
IT training	0.098***	0.099***	0.097***
	(2.81)	(2.84)	(2.78)
% employees using computer	0.102*	0.102*	0.098
	(1.66)	(1.66)	(1.60)
% high-skilled employees	0.067	0.069	0.073
	(0.66)	(0.67)	(0.71)
% medium-skilled employees	-0.053	-0.053	-0.049
	(-0.67)	(-0.67)	(-0.61)
Log(num. of employees)	0.147***	0.149***	0.151***
	(2.66)	(2.68)	(2.72)
Log(num. of employees)^2	-0.018***	-0.018***	-0.019***
	(-2.85)	(-2.87)	(-2.91)
Log(gross investment)	0.032***	0.032***	0.032***
	(2.62)	(2.62)	(2.62)
Export dummy	0.093***	0.092***	0.093***
	(2.73)	(2.71)	(2.73)
Number of observations	1453	1453	1453
Pseudo R^2	0.244	0.244	0.244

Probit estimations, marginal effects (at the average).
All estimations include controls for industries and for location in East Germany. t-values in brackets.
Significant at 1% ***, significant at 5% ** , significant at 10% *

Table 6: Estimation Results, Product Innovation, Manufacturing and Services

	Dependent Variable: Product Innovation 2010					
	Manufacturing			Services		
ITO dummy	-0.077			-0.042		
	(-1.63)			(-0.83)		
ITO partially		-0.080			-0.052	
		(-1.55)			(-0.97)	
ITO completely		-0.077			-0.016	
		(-1.15)			(-0.24)	
% share of ITO			-0.594**			-0.039
			(-2.41)			(-0.16)
(% share of ITO)^2			0.548**			0.011
			(2.26)			(0.04)
Product innovation 2007	0.310***	0.310***	0.309***	0.386***	0.388***	0.382***
	(7.13)	(7.12)	(7.08)	(9.73)	(9.75)	(9.66)
BPO dummy	0.029	0.029	0.031	-0.036	-0.035	-0.038
	(0.71)	(0.70)	(0.75)	(-0.83)	(-0.82)	(-0.89)
IT training	0.069	0.070	0.075	0.113**	0.114**	0.111**
	(1.48)	(1.47)	(1.58)	(2.35)	(2.37)	(2.32)
% employees using computer	0.079	0.078	0.066	0.085	0.087	0.081
	(0.83)	(0.83)	(0.70)	(1.07)	(1.09)	(1.01)
% high-skilled employees	0.303*	0.304*	0.337**	0.001	0.002	0.002
	(1.83)	(1.83)	(2.02)	(0.01)	(0.01)	(0.01)
% medium-skilled employees	-0.087	-0.087	-0.070	-0.006	-0.009	-0.006
	(-0.89)	(-0.89)	(-0.71)	(-0.05)	(-0.07)	(-0.04)
Log(num. of employees)	0.134*	0.135*	0.143*	0.155**	0.162**	0.152**
	(1.69)	(1.69)	(1.80)	(2.09)	(2.16)	(2.03)
Log(num. of employees)^2	-0.018**	-0.018**	-0.019**	-0.018**	-0.018**	-0.018**
	(-2.02)	(-2.02)	(-2.11)	(-2.05)	(-2.09)	(-2.02)
Log(gross investment)	0.046***	0.046***	0.048***	0.016	0.016	0.016
	(2.70)	(2.70)	(2.78)	(1.00)	(0.99)	(0.96)
Export dummy	0.119**	0.118**	0.126***	0.062	0.060	0.060
	(2.44)	(2.44)	(2.60)	(1.26)	(1.22)	(1.23)
Number of observations	707	707	707	746	746	746
Pseudo R^2	0.211	0.211	0.215	0.251	0.252	0.251

Probit estimations, marginal effects (at the average), t-values in brackets.
All estimations include controls for industries and for location in East Germany.
Significant at 1% ***, significant at 5% ** , significant at 10% *

Table 7: Estimation Results, Process Innovation, Full Sample

	Dependent Variable: Process Innovation 2010		
ITO dummy	0.062*		
	(1.94)		
ITO partially		0.084**	
		(2.53)	
ITO completely		0.004	
		(0.10)	
% share of ITO			0.357**
			(2.19)
(% share of ITO)^2			-0.363**
			(-2.24)
Process innovation 2007	0.231***	0.230***	0.230***
	(8.21)	(8.14)	(8.17)
BPO dummy	0.041	0.042	0.044
	(1.48)	(1.51)	(1.60)
IT training	0.090***	0.084***	0.089***
	(2.91)	(2.70)	(2.87)
% employees using computer	0.121**	0.121**	0.125**
	(2.17)	(2.17)	(2.25)
% high-skilled employees	0.010	0.001	0.001
	(0.11)	(0.01)	(0.02)
% medium-skilled employees	-0.004	-0.006	-0.005
	(-0.05)	(-0.08)	(-0.07)
Log(num. of employees)	0.055	0.048	0.053
	(1.08)	(0.94)	(1.04)
Log(num. of employees)^2	-0.003	-0.002	-0.003
	(-0.43)	(-0.37)	(-0.43)
Log(gross investment)	0.017	0.017	0.017
	(1.57)	(1.53)	(1.58)
Export dummy	0.032	0.036	0.035
	(1.02)	(1.15)	(1.12)
Number of observations	1453	1453	1453
Pseudo R^2	0.110	0.112	0.111

Probit estimations, marginal effects (at the average).
All estimations include controls for industries and for location in East Germany. t-values in brackets.
Significant at 1% ***, significant at 5% ** , significant at 10% *

Table 8: Estimation Results, Process Innovation, Manufacturing and Services

	Dependent Variable: Process Innovation 2010					
		Manufacturing			**Services**	
ITO dummy	0.029			0.099**		
	(0.62)			(2.23)		
ITO partially		0.052			0.119***	
		(1.06)			(2.63)	
ITO completely		-0.030			0.037	
		(-0.48)			(0.66)	
% share of ITO			0.172			0.537**
			(0.72)			(2.38)
(% share of ITO)^2			-0.230			-0.497**
			(-0.97)			(-2.22)
Process innovation 2007	0.229***	0.228***	0.228***	0.224***	0.223***	0.223***
	(5.59)	(5.57)	(5.57)	(5.69)	(5.64)	(5.66)
BPO dummy	0.111***	0.113***	0.120***	-0.017	-0.018	-0.016
	(2.77)	(2.83)	(2.99)	(-0.44)	(-0.46)	(-0.41)
IT training	0.050	0.039	0.044	0.121***	0.118***	0.123***
	(1.09)	(0.85)	(0.98)	(2.79)	(2.72)	(2.83)
% employees using computer	0.093	0.096	0.100	0.111	0.108	0.111
	(1.02)	(1.06)	(1.10)	(1.54)	(1.50)	(1.54)
% high-skilled employees	0.097	0.084	0.087	0.074	0.067	0.070
	(0.65)	(0.56)	(0.58)	(0.58)	(0.53)	(0.55)
% medium-skilled employees	-0.093	-0.097	-0.089	0.145	0.144	0.138
	(-0.98)	(-1.01)	(-0.93)	(1.30)	(1.29)	(1.23)
Log(num. of employees)	0.004	0.005	0.017	0.102	0.090	0.093
	(0.05)	(0.06)	(0.21)	(1.52)	(1.32)	(1.38)
Log(num. of employees)^2	0.003	0.003	0.002	-0.008	-0.007	-0.007
	(0.36)	(0.32)	(0.21)	(-0.94)	(-0.84)	(-0.83)
Log(gross investment)	0.039**	0.039**	0.039**	-0.003	-0.003	-0.003
	(2.33)	(2.27)	(2.33)	(-0.20)	(-0.21)	(-0.21)
Export dummy	0.054	0.056	0.056	0.007	0.013	0.013
	(1.14)	(1.17)	(1.17)	(0.17)	(0.30)	(0.30)
Number of observations	707	707	707	746	746	746
Pseudo R^2	0.128	0.130	0.130	0.112	0.114	0.112

Probit estimations, marginal effects (at the average), t-values in brackets.
All estimations include controls for industries and for location in East Germany.
Significant at 1% ***, significant at 5% ** , significant at 10% *

Table 9: Propensity Score Matching, Process Innovation, First Stage Results

	Dependent Variable: ITO dummy					
	Full sample		**Manufacturing**		**Services**	
% IT specialists	-0.295***	(-3.59)	-0.327	(-1.46)	-0.319***	(-3.51)
Log(local IT-suppliers)	0.035**	(2.01)	0.035	(1.40)	0.042*	(1.72)
Consortium dummy	-0.045	(-1.50)	0.015	(0.35)	-0.086**	(-2.06)
Process innovation 2007	0.018	(0.69)	-0.015	(-0.44)	0.061*	(1.65)
BPO dummy	0.119***	(4.79)	0.134***	(3.86)	0.107***	(3.02)
IT training	0.100***	(3.45)	0.115***	(2.82)	0.080**	(1.96)
% employees using computer	0.170***	(3.34)	0.103	(1.27)	0.239***	(3.54)
% high-skilled employees	0.075	(0.95)	-0.015	(-0.12)	0.088	(0.80)
% medium-skilled employees	0.183***	(3.01)	0.220***	(2.72)	0.131	(1.38)
Log(num. of employees)	0.145***	(3.09)	0.184**	(2.56)	0.119*	(1.89)
Log(num. of employees)^2	-0.012**	(-2.19)	-0.015*	(-1.69)	-0.011	(-1.49)
Log(gross investment)	0.032***	(3.36)	0.033**	(2.18)	0.034***	(2.63)
Export dummy	0.065**	(2.35)	0.023	(0.57)	0.097***	(2.72)
Number of observations	1453		707		746	
Pseudo R^2	0.146		0.179		0.138	

Probit estimations, marginal effects (at the average), t-values in brackets.
All estimations include controls for industries and for location in East Germany.
Significant at 1% ***, significant at 5% ** , significant at 10% *

Table 10: Results Before and After Matching, Full Sample

	Unmatched		**Matched**	
Groups of firms	**ITO**	**Non-ITO**	**ITO**	**Non-ITO**
% IT specialists	0.074	0.153***	0.075	0.074
Log(local IT-suppliers)	7.915	7.790**	7.903	7.904
Consortium dummy	0.359	0.271***	0.359	0.358
Process innovation 2007	0.673	0.592**	0.668	0.658
BPO dummy	0.538	0.488*	0.528	0.496
IT training	0.681	0.478***	0.673	0.678
% employees using computer	0.491	0.475	0.484	0.496
% high-skilled employees	0.219	0.254**	0.220	0.237
% medium-skilled employees	0.610	0.566***	0.607	0.594
Log(num. of employees)	3.907	3.110***	3.860	3.905
Log(num. of employees)^2	17.261	11.113***	16.836	17.228
Log(gross investment)	-1.491	-2.627***	-1.571	-1.600
Export dummy	0.519	0.390***	0.518	0.510
Propensity score	0.777	0.611***	0.771	0.771
Number of observations	1,066	387	1,033	387[a]

*** Mean difference between ITO and non-ITO firms is significant at 1%,
** significant at 5%, * significant at 10%
[a] Pool of non-ITO firms from which we draw the k(=5) nearest neighbours

Table 11: Results After Propensity Score Matching

	ITO firms	**Non-ITO firms**	**Difference**	**t-stat**
		Product Innovation 2010		
Full sample	0.562	0.593	-0.032	(-0.87)
Manufacturing	0.650	0.723	-0.073	(-1.09)
Services	0.460	0.465	-0.005	(-0.10)
		Process Innovation 2010		
Full sample	0.668	0.579	0.088**	(1.98)
Manufacturing	0.668	0.681	-0.013	(-0.22)
Services	0.658	0.531	0.128***	(2.67)

*** Mean difference between ITO and matched non-ITO firms is significant at 1%, ** significant at 5%, * significant at 10%